6. CONNECTION TUNNELS

Combined sewer overflows (CSOs) that are dropped from the consolidation sewers will be conveyed to the main tunnel through connection tunnels. Connection tunnels will be sized for 99 percent capture of CSOs, as requested by the City of Indianapolis Department of Public Works (DPW). This will allow for flexibility in the operation of the system, particularly if the storm event does not cover the entire watershed, and the tunnel system is expanded in the future to achieve a 99 percent capture rate.

6.1 METHODOLOGY FOR DETERMINING CONNECTION TUNNEL LOCATIONS

Connection tunnels are presented on Figures 3.2 through 3.4 in Section 3 – Fall Creek/White River Tunnel for each alignment alternative. Connection tunnel lengths were minimized to the extent practical by:

- Routing the main tunnel to generally follow the Fall Creek and White River
- Locating drop shafts close to the main tunnel
- Using one primary connection tunnel to convey CSOs from multiple consolidation sewers to the main tunnel alignment

Depending on the selected working and retrieval shafts, the West main tunnel alignment may have connection tunnels constructed only in rock. The Central and East main tunnel alignments have connection tunnels that are anticipated to be constructed in rock and soil. Drop shafts (DS) and associated connection tunnels located adjacent to and generally within 1,000 feet of the main tunnel will be more economical to be constructed in rock. Longer connection tunnels were evaluated to determine if they should be constructed in soil or rock. In general, it will be more cost effective and less disruptive to the community to locate longer connection tunnels from individual drop shafts in rock. However, connection tunnels that intercept multiple drop shafts (i.e., DS-19, DS-20 and DS-21 if the Sutherland Avenue retrieval shaft is selected) are expected to be more cost effective when constructed in soil. Since shallow shafts are less costly to construct, the anticipated higher cost associated with soft ground tunneling is offset. At the down slope end of each soft

6. CONNECTION TUNNELS

ground connection tunnel, a deep shaft and short rock tunnel will be necessary to drop the flows to the main tunnel.

6.2 CONNECTION TUNNEL CONSIDERATIONS

The horizontal and vertical alignment of each connection tunnel was evaluated and selected based on cost and the following considerations:

- Drop shaft locations
- Available geotechnical and hydrogeologic information
- Real estate and underground easement requirements
- Presence of municipal and high capacity wells
- Socio-economic impacts
- Contamination
- Structures along the soft ground tunnel alignments (settlement)
- Utilities along the soft ground tunnel alignments
- Remaining within tunnel boring machine (TBM) or earth pressure balanced machine (EPBM) radii constraints, if used

Connection tunnels constructed in rock can be routed in a straight line. However, these tunnels may be curved to address easement acquisition and property issues. To promote hydraulic flow, the connection tunnels will intersect the main tunnel at an angle up to 45 degrees. Soft ground connection tunnels will be routed to minimize surface disruptions, community impacts and easements; and to avoid existing utilities and underground structures.

If the Sutherland Avenue retrieval shaft site is selected, the proposed soft ground connection tunnel at the northern end of the alignment will be routed in a straight line between the main tunnel and drop shaft DS-21. As shown on Figures 3.2 through 3.4 in Section 3 – Fall Creek/White River Tunnel, most of this connection tunnel alignment is routed under Fall Creek Parkway. Drop shafts DS-19 and DS-20 would connect directly to this tunnel through short, soft ground tunnels.

6. CONNECTION TUNNELS

As shown on Figures 3.3 and 3.4 in Section 3 – Fall Creek/White River Tunnel, a significant soft ground tunnel with multiple drops along the White River also would be required if the East or Central main tunnel alignment was selected. This soft ground tunnel was routed around significant structures because of the settlement potential inherent to soft ground tunneling, and to minimize the connection lengths.

6.3 CONNECTION TUNNEL SIZES

Tables 6.1, 6.2, and 6.3 present the connection tunnel sizes associated with the West, Central and East main tunnel alignments, respectively. The connection tunnel sizes assume the Bluff Road working shaft and Sutherland Avenue retrieval shaft sites are selected. In addition, the tables indicate the geologic media (soil or rock) that each connection tunnel is anticipated to be constructed in if these working and retrieval shafts are selected. Along Fall Creek, the connection tunnel diameters were sized based on 99 percent capture of CSOs flowing at a velocity of 3.5 feet per second (fps). Flow information was unavailable at the time of this study for the White River CSOs. Flows were assumed, as described in Section 5 – Consolidation Sewers and Drop Shafts, to develop preliminary estimates for the White River connection tunnel diameters and cost estimating purposes. The connection tunnel sizes will be reviewed and resized as appropriate during design. It is anticipated that these connection tunnels will add between 15 to 20 million gallons (MG) of storage to the tunnel system. However, this storage has not been accounted for in the overall volume of the main tunnel.

6. CONNECTION TUNNELS

Table 6.1
West Alignment Connection Tunnels [1, 2]

Connection Tunnel			
Description	**Length, ft**	**Diameter, ft**	**Depth (soil or rock)**
DS-01 to Main Tunnel	790	6	Rock
DS-02 to Main Tunnel	1,310	9	Rock
DS-03 to Main Tunnel	250	8	Rock
DS-04 to Main Tunnel	660	6	Rock
DS-05 to Main Tunnel	50	6	Rock
DS-06 to Main Tunnel	470	6	Rock
DS-07 to Main Tunnel	860	6	Rock
DS-08 to Main Tunnel	60	6	Rock
DS-09 to Main Tunnel	1,700	7	Rock
DS-10 to Main Tunnel	4,100	7	Rock
DS-11 to Main Tunnel	210	13	Rock
DS-12 to Main Tunnel	730	15	Rock
DS-13 to Main Tunnel	150	7	Rock
DS-14 to Main Tunnel	480	15	Rock
DS-15 to Main Tunnel	400	6	Rock
DS-16 to Main Tunnel	210	6	Rock
DS-17 will be open cut to Sutherland Avenue retrieval shaft and dropped; no connection tunnel is needed.			
DS-18 to Retrieval Shaft	1,470	6	Rock
DS-19 to DS-21 Connection Tunnel	290	10	Soil
DS-20 to DS-21 Connection Tunnel	250	10	Soil
DS-21 to Retrieval Shaft	5,130	16	Soil
CSO outfall 117 to Main Tunnel	600	11	Rock
Total Length of West Alignment Connection Tunnels = 20,170			

[1] Assumes Bluff Road working shaft site and Sutherland Avenue retrieval shaft site are used.
[2] Flow information was unavailable at the time of this study for White River CSO outfalls. Estimates for tunnel diameters were developed as described in Section 5 – Consolidation Sewers & Drop Shafts. A flow rate equally to the CSO outfall diameter flowing full at a velocity of 2.5 fps was assumed for each outfall along White River.

6. CONNECTION TUNNELS

Table 6.2
Central Alignment Connection Tunnels [1, 2]

Connection Tunnel			
Description	**Length, ft**	**Diameter, ft**	**Depth (soil or rock)**
DS-01 to Main Tunnel	790	6	Rock
DS-02 to Main Tunnel	1,310	9	Rock
DS-03 to Main Tunnel	250	8	Rock
DS-04 to Main Tunnel	2,230	12	Rock
DS-05 to DS-08 Connection Tunnel	180	6	Soil
DS-06 to DS-08 Connection Tunnel	450	6	Soil
DS-07 to DS-08 Connection Tunnel	870	6	Soil
DS-08 to DS-04 Connection Tunnel	6,970	10	Soil
DS-09 to DS-08 Connection Tunnel	1,750	7	Soil
DS-10 to Main Tunnel	230	7	Rock
DS-11 to Main Tunnel	1,220	13	Rock
DS-12 to Main Tunnel	50	15	Rock
DS-13 to Main Tunnel	150	7	Rock
DS-14 to Main Tunnel	480	15	Rock
DS-15 to Main Tunnel	400	6	Rock
DS-16 to Main Tunnel	210	6	Rock
DS-17 will be open cut to Sutherland Avenue retrieval shaft and dropped; no connection tunnel is needed.			
DS-18 to Retrieval Shaft	1,470	6	Rock
DS-19 to DS-21 Connection Tunnel	290	10	Soil
DS-20 to DS-21 Connection Tunnel	250	10	Soil
DS-21 to Retrieval Shaft	5,130	16	Soil
CSO outfall 117 to Main Tunnel	600	11	Rock
Total Length of Central Alignment Connection Tunnels = 25,280			

[1] Assumes Bluff Road working shaft site and Sutherland Avenue retrieval shaft site are used.
[2] Flow information was unavailable at the time of this study for White River CSO outfalls. Estimates for tunnel diameters were developed as described in Section 5 – Consolidation Sewers & Drop Shafts. A flow rate equally to the CSO outfall diameter flowing full at a velocity of 2.5 fps was assumed for each outfall along White River.

6. CONNECTION TUNNELS

Table 6.3
East Alignment Connection Tunnels [1, 2]

Connection Tunnel			
Description	**Length, ft**	**Diameter, ft**	**Depth (soil or rock)**
DS-01 to Main Tunnel	790	6	Rock
DS-02 to Main Tunnel	1,310	9	Rock
DS-03 to Main Tunnel	250	8	Rock
DS-04 to Main Tunnel	2,230	12	Rock
DS-05 to DS-08 Connection Tunnel	180	6	Soil
DS-06 to DS-08 Connection Tunnel	450	6	Soil
DS-07 to DS-08 Connection Tunnel	870	6	Soil
DS-08 to DS-04 Connection Tunnel	6,970	10	Soil
DS-09 to DS-08 Connection Tunnel	1,750	7	Soil
DS-10 to Main Tunnel	1,120	7	Rock
DS-11 to Main Tunnel	3,440	13	Rock
DS-12 to Main Tunnel	50	15	Rock
DS-13 to Main Tunnel	150	7	Rock
DS-14 to Main Tunnel	480	15	Rock
DS-15 to Main Tunnel	400	6	Rock
DS-16 to Main Tunnel	210	6	Rock
DS-17 will be open cut to Sutherland Avenue retrieval shaft and dropped; no connection tunnel is needed.			
DS-18 to Retrieval Shaft	1,470	6	Rock
DS-19 to DS-21 Connection Tunnel	290	10	Soil
DS-20 to DS-21 Connection Tunnel	250	10	Soil
DS-21 to Retrieval Shaft	5,130	16	Soil
CSO outfall 117 to Main Tunnel	600	11	Rock
Total Length of East Alignment Connection Tunnels = 28,390			

[1] Assumes Bluff Road working shaft site and Sutherland Avenue retrieval shaft site are used.
[2] Flow information was unavailable at the time of this study for White River CSO outfalls. Estimates for tunnel diameters were developed as described in Section 5 – Consolidation Sewers & Drop Shafts. A flow rate equally to the CSO outfall diameter flowing full at a velocity of 2.5 fps was assumed for each outfall along White River.

6. CONNECTION TUNNELS

6.4 CONNECTION TUNNEL LAYOUT NEAR WORKING AND RETRIEVAL SHAFTS

Depending on the working shaft or retrieval shaft considered, the connection tunnel lengths vary in the southern and northern portions of each main tunnel alignment. The connection tunnels from drop shafts to the Bluff Road or Reilly working shafts will be longer than those to the Southern Avenue working shaft. The connection tunnel from CSO outfall 117 to the Reilly working shaft will be longer than those associated with the Southern Avenue or Bluff Road working shafts. As shown on Figures 3.2 through 3.4 in Section 3 – Fall Creek/White River Tunnel, there are two retrieval shaft site alternatives. These include the Keystone Dam retrieval shaft site and the Sutherland Avenue retrieval shaft site. If the Keystone Dam retrieval shaft site is selected, drop shafts DS-19 and DS-21 would be constructed in rock and connected to the main tunnel using relatively short rock tunnels. Drop shaft DS-20 could be eliminated by constructing an open-cut sewer from CSO outfall 135 to the Keystone Dam retrieval shaft. The Keystone Dam retrieval shaft location would function as the drop shaft location for CSO outfall 135. If the Sutherland Avenue retrieval shaft site is selected, drop shafts DS-19, DS-20 and DS-21 would be constructed in soil and connected to the main tunnel using soft ground tunnel construction.